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DIELECTRIC-COATED SPHERICALLY-TIPPED METAL CONE ANTENNAS EXCITED IN THE UNSYMMETRIC HYBRID MODE AT MICROWAVE FREQUENCIES

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Theoretical and experimental work on the radiation, gain and impedance of dielectric-coated spherically-tipped metal cone antennas have been carried out. The antennas have been excited in the unsymmetric hybrid mode from the open end of a cylindrical metal waveguide carrying the dominant TE_{11} mode (Fig.1).

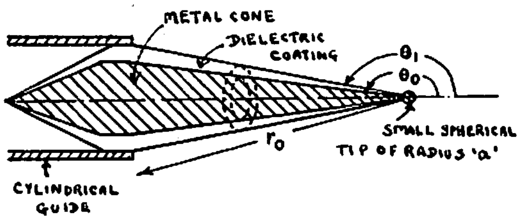

Fig.1

The radiation from the antenna has been theoretically calculated by making use of Schelkunoff's Equivalence Principle. An estimate of the electric and magnetic currents on the antenna has been made knowing the surface electric and magnetic currents on the inside surface of the cylindrical metal waveguide. The radiation diagrams for varying lengths and cone angles of perspex-coated metal antennas have been calculated in the principal $\phi = 0°$ plane and verified with experimental results.

The expression given below (Eqn.1) gives the far-field E in the $\phi = 0°$ plane.

$$E \propto \sin\theta_0 \int_{r'=a}^{r_0} \left[J_2(k_0 r' \sin\theta_0 \sin\theta) + J_0(k_0 r' \sin\theta_1 \sin\theta)\right] r' e^{-jk_0 r'\left(\frac{k_2}{k_0} + \cos\theta_0 \cos\theta\right)} dr' + \sin\theta_1 \int_{r'=a}^{r_0} \left[J_2(k_0 r' \sin\theta_1 \sin\theta) + J_0(k_0 r' \sin\theta_1 \sin\theta)\right] r' e^{-jk_0 r'\left(\frac{k_2}{k_0} + \cos\theta_1 \cos\theta\right)} dr' \qquad \text{——(1)}$$

where

r_0 = length of antenna
a = radius of metal spherical tip
$2\theta_0$ = angle of metal cone
$2\theta_1$ = angle of dielectric cone
$k_0 = 2\pi/\lambda_0$, $k_2 = 2\pi/\lambda_g$
λ_0 = free space wavelength
λ_g = guide wavelength
J_2, J_0 are Bessel functions.

Knowing the radiation field of the antenna, the gain of the antenna has been calculated and also verified by experiment.

The agreement between theoretical and experimental results for both the radiation patterns and the gain is good.

Measurements on the input impedance of the antennas have been made for varying dimensions. The results of these investigations on dielectric-coated spherically tipped metal cone antennas show that:

(i) these antennas behave like end-fire antennas with a major lobe in the axial direction whose beamwidth is small, and the side lobes are very small compared to the major lobe. The side lobe level is usually more than twenty decibels below the major lobe level;

(ii) the measured gain of the antennas is of the order of fifteen decibels;

(iii) for fixed length of the antenna, the beamwidth of the major lobe may be made very small by a proper choice of angles of the cones, at a slight increase in side-lobe level;

(iv) the impedance of the antenna does not vary very much with the dimensions; and

(v) since the variation of the impedance as well as that of the beamwidth of the major lobe and that of the gain with the dimensions is small, the antenna has broad-band characteristics.

Fig.2 shows the calculated radiation pattern and the experimental pattern in the $\phi = 0°$ plane for $\theta_0 = 175° 52'$, $\theta_1 = 174°50'$, $r_0/\lambda_0 = 4.7$ for a perspex-coated spherically tipped metal cone antenna.

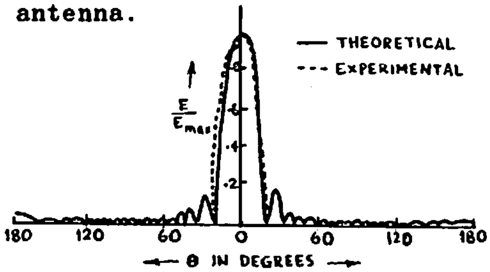

FIG. 2

Fig.3 shows the beamwidth θ_B of the major lobe versus length of the antenna in wavelengths for the same values of θ_0 and θ_1.

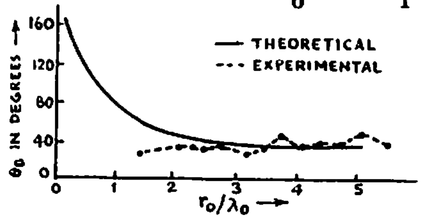

FIG. 3

Fig.4 shows the measured and theoretical gain as a function of length of the antenna in wavelengths for the same value of θ_0 and θ_1.

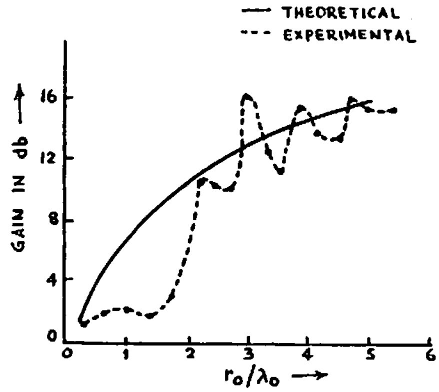

FIG. 4

Fig.5 shows the measured impedance as a function of the length of the antenna in wavelengths for the same values of θ_0 and θ_1.

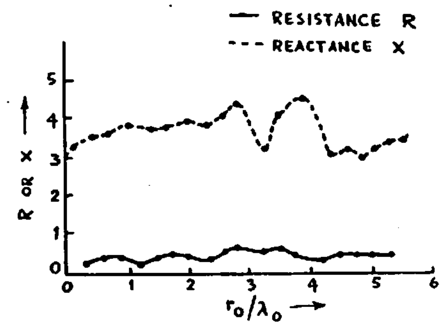

FIG. 5